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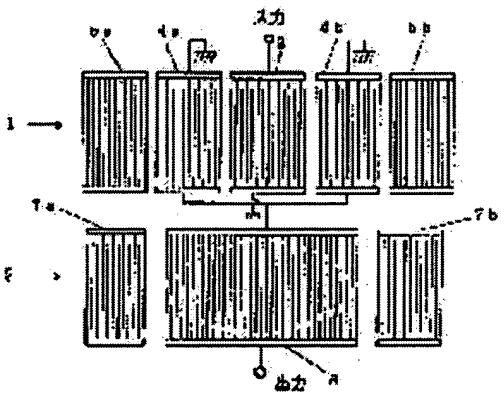
(54) SURFACE ACOUSTIC WAVE FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To suppress the increase in a loss and to obtain an excellent cut-off characteristic and an attenuation characteristic in the vicinity of high frequencies by connecting a resonator to terminals of IDTs at both sides among three interdigital transducers(IDTs).

SOLUTION: A longitudinally coupled dual mode surface acoustic wave (SAW) filter (longitudinally coupled DMS filter) 1 of 3-IDT configuration is made up of IDTs 3, 4a, 4b and reflectors 5a, 5b. A pattern pitch, number of electrodes and an interval of electrodes are selected to realize a desired pass band. A SAW resonator 2 is connected in series with an output terminal obtained by connecting electrodes of the IDTs 4a, 4b in parallel. The resonator 2 is made up of the IDT 6 in which electrode finger cross lengths to stimulate a surfaced acoustic wave are given a cosine type, weighting and reflectors 7a, 7b on its both sides. The resonance frequency of the resonator 2 is set to be in the pass band of the filter 1 and the anti-resonance frequency is set to be on the high frequency side of the pass band of the filter 1.



LEGAL STATUS

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the surface-acoustic-wave filter which has improved the magnitude of attenuation by the side of a passage region cut off characteristic and high region close attendants especially along the surface wave propagation direction on three interchange digital transducers (henceforth IDT), and this maximum outside of IDT about the surface-acoustic-wave filter (henceforth an SAW filter) which comes to arrange two reflectors on a piezo-electric substrate.

[0002]

[Description of the Prior Art] since a surface acoustic wave has the various features it is featureless to the conventional oscillating device -- that the oscillating field is limited to a front face, and an amplitude and a phase can be designed separately -- also in the field of a fundamental research, research also accomplishes an applied field at an energy target, and it is used for various kinds of equipments at present Since it is suitable for small and mass production method it is strong and according to batch processing and a low cost is expectable especially, it is mostly used for the latest mobile communications, especially the latest cellular phone. It sets to Proc.of 1980 IEEE Ultrasonics Symposium pp.164-168 especially. It is proposed by Rosenberg R.L. and Coldren L.A. The vertical joint double mode SAW filter (henceforth a vertical joint DMS filter) of 3IDT composition put in practical use by Morita, Watanabe and others in electronic-intelligence communication society technical report US-92-8 It is low loss and the passage region has the outstanding feature that it is flat and a cut-off can realize a steep property.

[0003] The ** type view of the vertical joint DMS filter of the 3above-mentioned IDT composition is shown in drawing 5 . On the main front face of the piezo-electric substrate 8, a vertical joint DMS filter has the structure which approached and has arranged Reflectors 11a and 11b along the propagation direction on the maximum outside of IDT(s) 9, 10a, and 10b and this IDT, makes an input terminal one side of the electrode which IDT9 counters, and grounds another side. furthermore, drawing 5 -- like -- IDT(s) 10a and 10b -- common connection of one [each] electrode is made, it considers as an output terminal, and the electrode of another side is grounded Here, an input terminal and an output terminal may be decided for convenience, and may be replaced mutually.

[0004] the proper arrangement of IDT(s) 9, 10a, and 10b and Reflectors 11a and 11b shown in drawing 5 -- the bottom of Above IDT -- an acoustic turnover -- being generated -- the result -- two -- it shuts up and the mode, i.e., the primary longitudinal mode and the Miyoshi longitudinal mode, is excited by stress If frequency in these modes is set to f1 and f3, respectively, it will be f3<f1 and the vertical joint DMS filter of 2 (f1-f3) will be obtained [center frequency] for bandwidth by f1. An example of the filtering property at the time of forming a vertical joint DMS filter on a 36-degree Y-X lithium tantalate ($LiTaO_3$) substrate at drawing 6 is shown. The unsymmetrical property produced in the high region side near the passage region is an essential fault peculiar to a vertical joint DMS filter spurious one decided by the logarithm of I/O IDT so that more clearly than drawing 6 . Only about 12-13dB, the spurious magnitude of attenuation does not exist, and when it is going to apply to RF filter for cellular phones with which the frequency of transmission and reception is close, it poses a big problem.

[0005] As shown in drawing 7 as a means to solve spurious one near [above-mentioned] the passage

region, the 1 terminal-pair type resonators 13 and 14 are connected to I/O of the vertical joint DMS filter 12 in series, and the proposal which is going to improve the magnitude of attenuation by the side of the high region near the passage region is performed using the attenuation pole constituted from antiresonant frequency of these resonators. (The 1994 ****** autumn convention besides Nagatsuka, No.1, P.230, JP,7-30367,A, JP,7-86870,A)

[0006] The above-mentioned improvement method is explained using drawing 8 . Drawing 8 (a) shows the circuitry view which connected the 1 terminal-pair type SAW resonator (henceforth a SAW resonator) to I/O of a vertical joint DMS filter (DMSF and brief sketch) in series, respectively. Drawing 8 (b) is what showed the filtering property (equivalent to drawing 6) of the aforementioned vertical joint DMS filter, and spurious one mentioned above to the high region side near the passage region has generated it. Drawing 8 (c) is what showed the transmission characteristic of a SAW resonator, and it means that an attenuation pole arises in antiresonant frequency. The resonance frequency of this SAW resonator is set up so that it may be mostly in agreement with the passage region of the aforementioned vertical joint DMS filter, and it sets up so that it may be mostly in agreement with the frequency in which spurious one in the high region side near the passage region of the aforementioned vertical joint DMS filter generates antiresonant frequency further. Thus, if the series connection of the SAW resonator which set up frequency is carried out to a vertical joint DMS filter like drawing 8 (a), a comprehensive filtering property will turn into a property which has improved spurious one of a vertical joint DMS filter, as shown in drawing 8 (d).

[0007] An example of the actual measurement of the aforementioned SAW resonator is shown in drawing 9 . Drawing 9 (a) shows the Smith-chart view showing the frequency-impedance locus of a SAW resonator, the horizontal line of a diameter of circle expresses a resisted part (r), and the upper half of a circle expresses a positive reactance (+jx), and, as for the lower half, it expresses the negative reactance (-jx). That is, the frequency which crosses the horizontal line of a diameter is the frequency of phase zero, and the number wave number A of resonance or antiresonant frequency B is expressed. There is no tracing which draws a circle by the RF close-attendants side of antiresonant frequency B, and the frequency-impedance characteristic of the SAW resonator which arranged the usual regular type IDT has not produced resonance so that clearly from the Smith-chart view shown in drawing 9 (a). Moreover, measurement of the transmission characteristic of the aforementioned SAW resonator shows the single peak response in antiresonant frequency, as shown in drawing 9 (b). The example of a filtering property of the filter constituted like drawing 7 using the resonator of such regular type IDT is shown in drawing 10 . Bandwidth of frequency is about 36MHz in about 1.5GHz. the SAW resonator which carries out a series connection to a vertical joint DMS filter -- either of the I/O of a piece or at least two pieces or more -- one side -- good -- it could carry out and the frequency of resonators may be shifted mutually

[0008] Since the resonance frequency of the above-mentioned SAW resonator which carries out a series connection usually sets up so that it may become within filter passage mostly, the increase in the loss in the passband by SAW resonator addition is small. However, if the resonant resistance of a SAW resonator is the order which is about 1ohm at all and the series connection of two or more resonators is carried out, the increase in loss is caused and the problem and the bird clapper are clear. Moreover, at the antiresonating point of one resonator, since the frequency range which can keep attenuation large is narrow, although it is common to shift the antiresonant frequency of two resonators a little mutually, and to arrange it in the case of circuitry like drawing 7 , the increase in loss of a passage region becomes twice [about] in the case of a resonator piece in this case.

[0009] Drawing 10 is the example of a filtering property of composition of having carried out the

series connection of the SAW resonator to each input/output terminal of a vertical joint DMS filter like drawing 7 , and has connected the SAW resonator with low frequency to the center IDT (input) side shown in drawing 7 . Although the spurious magnitude of attenuation in the RF side of a passage region has improved, a cut off characteristic is not smooth and a portion like a plateau remains. If the antiresonant frequency of the aforementioned SAW resonator is made to approach a filter passage region side further in order to remove spurious one like this plateau, it will become the property that the right shoulder of a passage region property is missing like ** shown in drawing 11 .

[0010]

[Problem(s) to be Solved by the Invention] However, in the magnitude-of-attenuation improvement by the series connection of the conventional SAW resonator, when the magnitude of attenuation was secured in the to some extent large range, two or more SAW resonators which shifted antiresonant frequency were needed. Moreover, the frequency relation of the height of the SAW resonator linked to each input/output terminal of a vertical joint DMS filter might not be specified, and a cut off characteristic might not become smooth by the case, but the right shoulder of a filter passage region property might be missing. this invention is made in order to remove these faults, in a frequency range larger than before, the fixed magnitude of attenuation is secured by one resonator, and it aims at minimizing the increase in loss of a passage region, and offering the surface-acoustic-wave filter which has a good cut off characteristic.

[0011]

[The means for solving invention] this invention in order to attain the above-mentioned purpose in a claim 1 Two reflectors are arranged along the propagation direction of a surface acoustic wave on the maximum outside of three IDT(s) and this IDT on a piezo-electric substrate. Central IDT in series in an input terminal and the surface-acoustic-wave filter of both sides which carried out parallel connection of the two IDT(s), and was made into the output terminal It is the surface-acoustic-wave filter which connected the 1 terminal-pair type surface-acoustic-wave resonator which consists of IDT which carried out cosine type weighting, and a reflector of the both sides, and has arranged antiresonant frequency for the resonance frequency of this resonator rather than the passage region of the aforementioned filter in the passage region of the aforementioned filter at the RF side. Furthermore, in a claim 2, it is the surface-acoustic-wave filter which used the 36 rotation Y cut lithium tantalate for the piezo-electric substrate.

[0012]

[Embodiments of the Invention] Hereafter, this invention is explained in detail based on the form and experimental result of operation which were shown in the drawing. Drawing 1 of the vertical joint DMS filter 1 which is the ** type view of an IDT electrode having shown the composition of this invention, and consists of 3IDT(s) constituted from IDT(s) 3, 4a, and 4b and reflectors 5a and 5b of this maximum outside of IDT is the same as that of the conventional thing, and the pitch of a pattern, an electrode number, the interval of each electrode, etc. are chosen so that a desired passage region may be realized. Making one electrode of the center IDT3 of the vertical joint DMS filter 1 into an input terminal, an other-end child grounds. Moreover, parallel connection of one [each] electrode of IDT(s) 4a and 4b is carried out, it considers as an output terminal, and each other-end child is grounded. Furthermore, the SAW resonator 2 is connected to the aforementioned output terminal in series. The SAW resonator 2 consists of IDT6 in which the intersection length of the electrode finger which excites SAW did cosine (cos) type weighting, and reflectors 7a and 7b of the both sides. Moreover, these [IDT] and the electrode pattern of a reflector are produced by aluminum or the

aluminium alloy on the principal plane of a piezo-electric substrate.

[0013] The main point of this invention makes a cosine configuration the electrode finger decussation length of IDT of a SAW resonator who connects with a vertical joint DMS filter in series, and are the comprehensive filtering property of a filter, and improving the improvement of the magnitude of attenuation by the side of the RF near the passage region, and the cut off characteristic of a passage region especially. The advantage at the time of connecting the advantage and SAW resonator at the time of giving cosine type weighting or weighting near this to IDT6 to the both-sides IDT (output) side of a filter 1 is explained. The measurement result of a SAW resonator which becomes this invention at drawing 2 is shown. Drawing 2 (a) is the Smith-chart view of the frequency-impedance characteristic at the time of producing the SAW resonator 2 on a 36-degree Y-X lithium tantalate (LiTaO3) substrate, and has tracing which draws a small circle near antiresonant frequency B. It is clear that small resonance of Q exists in frequency somewhat higher than antiresonant frequency B from drawing 2 (a). The frequency-impedance characteristic of the SAW resonator at the time of not giving weighting to IDT6 but on the other hand, considering as a regular type does not show resonance as drawing 9 (a) mentioned above. It turns out that drawing 2 (b) is the transmission characteristic of the SAW resonator which carried out the aforementioned cosine configuration weighting, and has resonance small to the high region side of antiresonant frequency also from this view, and the damping property is broad compared with drawing 9 (b) by this.

[0014] The manufacture terms and conditions of the SAW resonator in which an intersection finger is cosine configuration weighting and had the property of drawing 2 , and the SAW resonator which had the property of drawing 9 by the conventional regular type IDT are made completely the same. Moreover, in the SAW resonator of the conventional regular type IDT, as shown in drawing 9 (a), there are few amounts of reflection by the side of the high region of the passage region containing antiresonant frequency B, compared with drawing 2 (a), the antiresonance is shallow, i.e., it turns out that the impedance of the antiresonance is small. When the difference among these properties carries out the series connection of the SAW resonator to a vertical joint DMS filter and uses it for it for a damping-property improvement, it appears as a difference of the superiority or inferiority of the attenuation by the side of the RF near the passage region. Namely, in the SAW resonator which becomes this invention shown in drawing 1 , as shown in drawing 2 , compared with the case where the SAW resonator which has the conventional property is used, the magnitude of attenuation can be earned in the larger range because of the existence of small resonance to the RF side near the antiresonant frequency B. Furthermore, if the SAW resonator which has a property as shown in drawing is used, the amount of reflection by the side of the high region containing antiresonant frequency B will become large, and since a steeper cut off characteristic and deep antiresonance, i.e., the neighboring impedance of antiresonant frequency B, are large, high attenuation can be obtained.

[0015] Drawing 3 is the example of a filtering property from which it constituted from composition of drawing 1 , i.e., a vertical joint DMS filter and one SAW resonator, and the intersection finger of a SAW resonator was obtained using IDT of a cosine configuration, and it has realized the steep cut off characteristic, without the right shoulder of a filter passage region being missing. Since a filter shape is common knowledge, although especially the filtering property is not illustrated, compared with the case where the SAW resonator of regular type IDT is used, a cut off characteristic is steep, and its attenuation by antiresonant frequency is large, and has improved it about 5dB also from attenuation 4 on frequency higher than antiresonant frequency. Moreover, the filtering property at the time of connecting with the center IDT3 (input) side of drawing 1 is shown in drawing 4 instead of connecting one SAW resonator 2 to both sides IDT. If a SAW resonator is connected to a center IDT3

(input) side with reference to drawing 4 so that clearly, the cut off characteristic by the side of the high region near the passage region will not become smooth, but a DIP as shown in drawing 4 will appear. Furthermore, when antiresonant frequency approaches a passage region, a passage ****** side will be missing and it will be more roundish.

[0016] The difference in the filtering property which was shown in a filtering property and drawing 4 with what [good] is shown in drawing 3 and which deteriorated has unsymmetrical I/O of a filter, and since the impedance characteristics of I/O differ, it takes place. although the Prior art had not shown clearly whether the SAW resonator which carries out a series connection should be connected to the side which is any by the side of IDT3 of the vertical joint DMS filter 1, or common connection of IDT(s) 4a and 4b, it has realized a good property like example drawing 3 for this clearly in this invention That is, if the low resonator of antiresonant frequency is connected to the common terminal of IDT(s) 4a and 4b and the high resonator of antiresonant frequency is connected to the common terminal of IDT(s) 4a and 4b, or IDT3 when connecting two or more SAW resonators to a vertical joint DMS filter in series and raising the attenuation by the side of the RF near the passage region, a cut off characteristic will not become round but will turn into a steep cut off characteristic. When the series connection of the resonator with frequency higher than the SAW resonator 2 is further carried out to the vertical joint DMS filter 1 of drawing 1 (concatenation is sufficient also as Center IDT side at a resonator 2) and the increase in the magnitude of attenuation is expected in it, since [of a passage region] the nearby cut off characteristic is mostly determined by the resonator 2, the degree of steepness hardly changes to it with the case of drawing 1 very much. That is, with the filter composition shown in drawing 1 , when raising the degree of steepness by the side of the high region near the passage region, if near attenuation level is obtained with the composition of a resonator piece, it is not necessary to add a resonator further. If it adds, in a passage region, the increase in the loss for a resonant resistance of a resonator will be caused on the contrary as usual.

[0017] In the property of the 3IDT length joint DMS filter simple substance shown in drawing 6 , the average insertion loss in the property of drawing 3 using the SAW resonator piece which becomes this invention is stopped by the increase (1.8dB and only 0.3dB) to the average insertion loss within the 35MHz bandwidth of passage **** being 1.5dB. However, in order to secure the magnitude of attenuation by the side of the RF near the passage region, when two SAW resonators by which the conventional proposal is made are used, as shown in drawing 10 , an average insertion loss will increase to 2.2dB. Received frequency is approaching [transmit frequencies] very much with 1477-1501MHz to 1429-1453MHz, and a domestic digital cellular phone (PDC) has the attenuation demand mentioned above especially in RF filter of a transmitting side. Simultaneously, since it is a big prerequisite that it is low loss, when it is going to realize this by the SAW filter, it can be said that the composition of drawing 1 in this invention is very effective.

[0018] In addition, the weighting configuration of the resonator in this invention is not what was restricted to the cosine (cos) type, and if it has an ellipse or an analogous form, an effect almost equivalent to having mentioned above will be acquired. Moreover, even if it connects a resonator with antiresonant frequency high further more to the composition of this invention shown in drawing 1 at Center IDT side, the outstanding cut off characteristic in this invention is maintained, and can expect the increase in the magnitude of attenuation.

[0019]
[Effect of the Invention] this invention is set in the SAW length joint double mode type filter of 3IDT composition. By connecting a resonator to the parallel connection terminal of both sides IDT in series, after taking an I/O impedance into consideration, and giving cosine (cos) or analogous weighting to

IDT of the resonator A deeper large antirésonance damping property can be acquired and the SAW filter which suppresses the increase in loss to minimum as a result, and has a damping property by the side of a good cut-off and high region close attendants can be realized.